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GROWTH OF HATCHERY-REARED Penaeus aztecus  
ON EXPERIMENTAL DIETS<sup>1</sup>

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ABSTRACT

During experimentation designed to determine the requirements for sexual maturation of brown shrimp (Penaeus aztecus) a series of diets were tested on juvenile and subadult shrimp. These diets were formulated from a series of compounds expected to provide the essential nutrients for growth and sexual maturation. Both natural and prepared foods (i.e., foods which have been processed for storage at room temperature) were tested. The ingredients of the foods tested and the processing methods used to stabilize the foods are described.

Growth rates and amounts of food consumed for shrimp reared on these diets are discussed, and growth is compared with that observed for wild shrimp. Implications of these growth rates to shrimp cultures are discussed. Experimental stunting of juvenile shrimp was investigated as a means of storing excess animals temporarily.

INTRODUCTION

As a part of studies designed to determine the nutritional and environmental requirements for sexual maturation of female brown shrimp (Penaeus aztecus) in captivity, the growth of juvenile shrimp has been studied on a variety of diets. Our philosophy has been that growth is a good indicator of the suitability

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of both the environment and the foods being tested. It is possible that nutrition and stresses during the juvenile stages have an effect on maturation later in the life of a shrimp.

Because shrimp grow poorly when fed any of the available compounded diets as their sole source of nutrition, nutrition was selected as a subject requiring some attention during our maturation studies. The approach being used is: first, to find natural foods which will encourage rapid growth and gonadal development, and second to learn which components of the natural food are essential. Work discussed in this paper deals only with early stages of this research.

In the course of experimentation with a promising natural food, shrimp "heads" (cephalothorax), a method was developed for destroying powerful enzymes present in shrimp heads without destroying their nutritional value thereby producing a food which can be preserved readily. This technique avoids the need to heat the product (the usual method of disinfecting the food and stabilizing enzymes), a process which apparently results in a loss of nutritional value to the shrimp.

#### MATERIALS AND METHODS

Brown shrimp were held either in 76 l aquaria, in 600 l tanks having a bottom area of 1 m<sup>2</sup>, or in 2400 l tanks with a bottom area of 3 m<sup>2</sup>. All tanks were equipped with under-gravel filters to circulate the water through an oyster shell substrate. The pH was maintained at about 7.5 by the buffering effect of the oyster shell. Temperatures were held between 27 and 29 C during experiments conducted in the 76 l and 600 l tanks. The 2400 l tanks were outdoors where water temperatures ranged from 14 to 31 C with a mean of 18.5 C.

Salinities were measured directly with a hand refractometer. When necessary, the salinity of the seawater used was increased by adding rock salt.

Length measurements were expressed as total length (tip of the rostrum to tip of the telson). Shrimp were wrapped in Kim-wipes<sup>2</sup> tissue for weighing. When daily or weekly measurements and weights were taken, the shrimp were handled with great care and at least 20% of the population was sampled. The shrimp were then returned to their respective tanks.

Shrimp heads that had been frozen soon after the heading operation were obtained from Gulf Fisheries, Inc. of Galveston. These heads were fed to shrimp as a control diet. The semi-moist compounded diet was prepared as follows:

<sup>2</sup>The use of trade names in this publication does not imply endorsement of commercial products.

1) Whole frozen shrimp heads were ground and treated with concentrated hydrochloric acid until the pH of the mixture reached 1.8. This mixture was allowed to stand for from 6 to 24 hours at room temperature.

2) A base, either ammonium hydroxide or sodium hydroxide, was added to the mixture until it reached a neutral pH (7.0).

3) Supplemental nutrients were added. The feed used in this study included 1% cholesterol, 0.2% corn oil, 2.4% dextrose, and 1% vitamin mixture.<sup>3</sup>

4) The mixture was bound with 5% gelatin that was dissolved in warm water and added to the other ingredients. After the ingredients were mixed they were placed in a refrigerator to gel.

5) The gel was cut into pieces of convenient size and dried in an air tunnel at room temperature.

Food was supplied in excess during all experiments. When information on quantity eaten was required, food was weighed before feeding and uneaten remains were removed and weighed. Allowance was made for the moisture absorbed by the remaining food. Food conversions were calculated on the basis of wet weight of feed to wet weight of tissue gained by the shrimp. Wet weight of feed was defined as feed having 80% water. Because the semi-dry prepared food contained only 35% water, weights of the semi-dry food were converted to equivalent weights containing 80% water so that food conversion calculations could be presented on a wet weight basis.

#### RESULTS

To evaluate the method of stabilizing shrimp enzymes present in the prepared food, a comparison was made between the acid-stabilized food and the same food stabilized by cooking. This experiment was conducted in the 2400 l tanks at a salinity of 32 to 36 ppt. Twenty-five shrimp were fed each test diet, and an additional group of 25 shrimp was fed the control diet--shrimp heads--for a period of 10 weeks. Growth on the cooked and uncooked diets was similar through the first 8 weeks (Figure 1); however, virtually no growth occurred in shrimp fed the cooked diet during the 9th and 10th weeks of the experiment.

A more striking difference was observed in the quantities of food consumed. During the 10-week period animals fed the cooked diet consumed about three times as much food as those fed the acid-stabilized diet. For each g of added shrimp weight food

<sup>3</sup>Vitamin diet fortification mixture obtained from Nutritional Biochemicals Co., Cleveland, Ohio.

was consumed at a rate of 18 g of shrimp heads, 22 g of acid-treated pellets, and 68 g of the cooked pellet.

In a second experiment conducted in the 600 l tanks at salinities of 32 to 36 ppt (Figure 2) growth of two groups of shrimp was almost identical on the prepared food and on shrimp heads for a period of 110 days. The groups of shrimp tested consisted of 50 animals each during the first 70 days, and 25 animals each for the remainder of the experiment. The curves for growth in weight between the sizes of 0.5 g and 6 g are only slightly curved indicating the daily growth increment in weight was nearly constant during the experiment. The common practice of feeding an amount equal to a fixed percentage of the total weight of the shrimp is not then, a suitable feeding procedure unless a large and changing proportion of the food ingested is required for maintenance. An estimate of food requirements for maintenance is discussed in a later paragraph on stunting. Since this estimate of maintenance requirements is relatively small, we recommend feeding shrimp a ration of fixed size through the size range of 0.5 to 6 g.

For comparative purposes the growth in length of shrimp is presented in Figure 3 along with a growth curve for brown shrimp held in ponds (Wheeler, 1967) and growth curves for wild shrimp derived from mark-recapture experiments in Texas (Neal, personal communication) and in North Carolina (McCoy, 1968).

Eight brown shrimp fed the prepared diet were held in the 76 l aquaria at each of four salinities (26, 32, 40, and 50 ppt) and temperatures of 27 to 29 C for 70 days as part of the maturation studies. Growth was much slower at 50 ppt than at the lower salinities and only slightly faster at 32 ppt than at either 26 ppt or 40 ppt under these temperature conditions (Figure 4). In their research on the effects of temperature and salinity Zein-Eldin (1963), Zein-Eldin and Aldrich (1965), and Zein-Eldin and Griffith (1969) have demonstrated that salinity within the range 10 ppt to 35 ppt has little effect on growth of postlarval brown shrimp.

Because of the apparent stunting effect observed at 50 ppt, another experiment was conducted in the 2400 l tanks in which 50 shrimp with an average weight of 2.5 to 3.0 g were held at 36 ppt, and 50 additional shrimp of similar size were held at 50 ppt. Growth curves for this experiment are presented in Figure 5. Virtually no growth occurred at 50 ppt salinity. After 20 days this group was split into two groups of 25 shrimp each. One of these groups was kept in the water of 50 ppt while the other was transferred to water of 36 ppt. Only 25 shrimp were retained in the group initially held at 36 ppt. Growth was resumed by the group transferred to water of 36 ppt salinity and the growth curve paralleled that of the group held throughout the experiment at 36 ppt. We concluded that holding shrimp at high salinity is a possible means of storing them for later use without reducing their ability to resume normal growth.

The shrimp held at 50 ppt consumed only a small amount of food per day (shrimp of 0.7 g to 1.0 g consumed 0.52 g of shrimp heads per shrimp per day). This value is an estimate of the food requirements for maintenance since only slight growth (13 mg per day) occurred; however, this estimate is probably too high since the high salinity caused unusual stresses on the shrimp.

An example more typical of food consumption and growth observed during this study is the consumption of 1.78 g of shrimp heads per day resulting in a weight increase of 92 mg per day observed at 32 ppt in 76 l aquaria.

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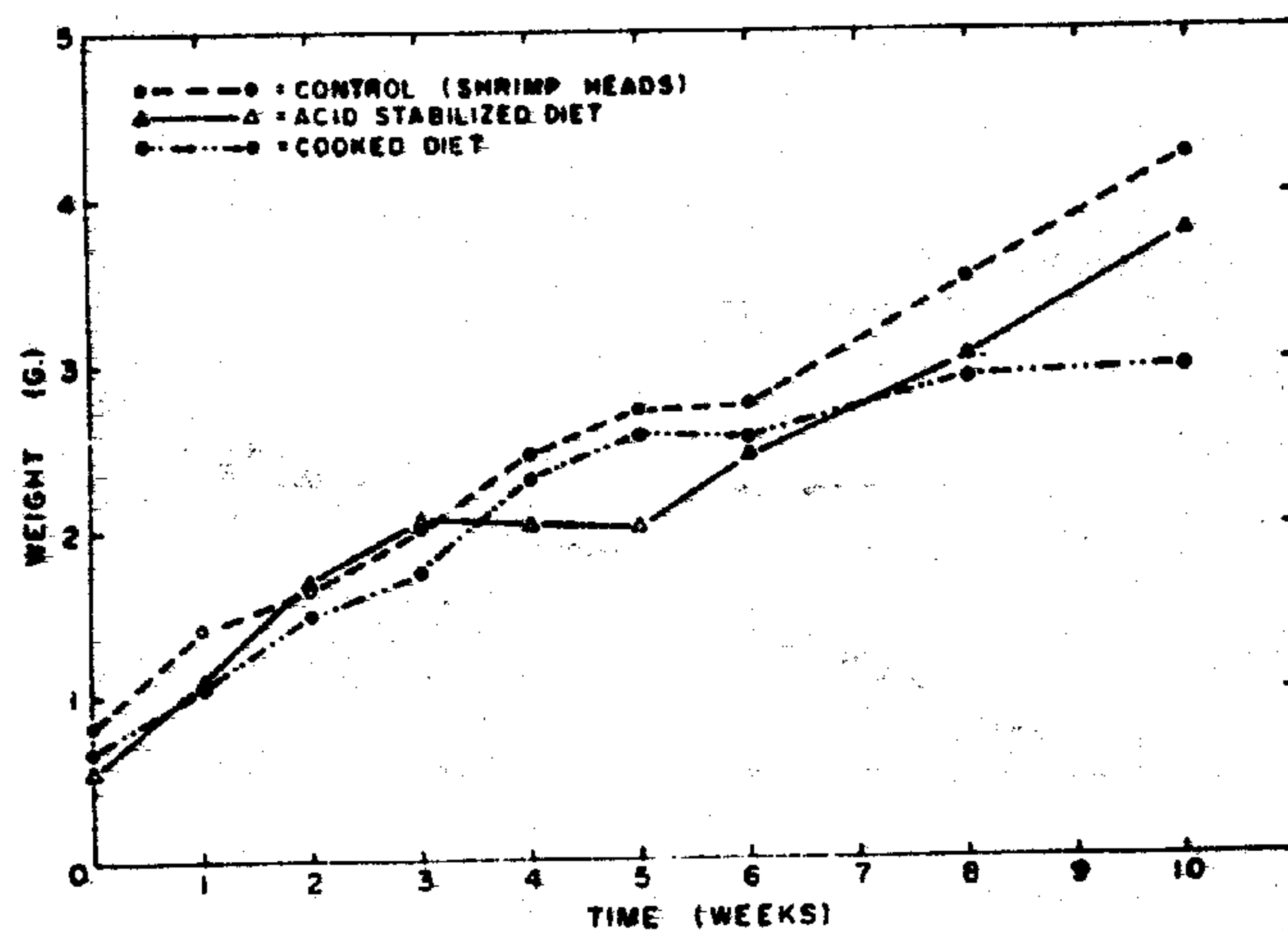


Figure 1. Growth of brown shrimp on a prepared diet stabilized by cooking, on the same diet stabilized with an acid treatment, and on a control diet of shrimp heads.

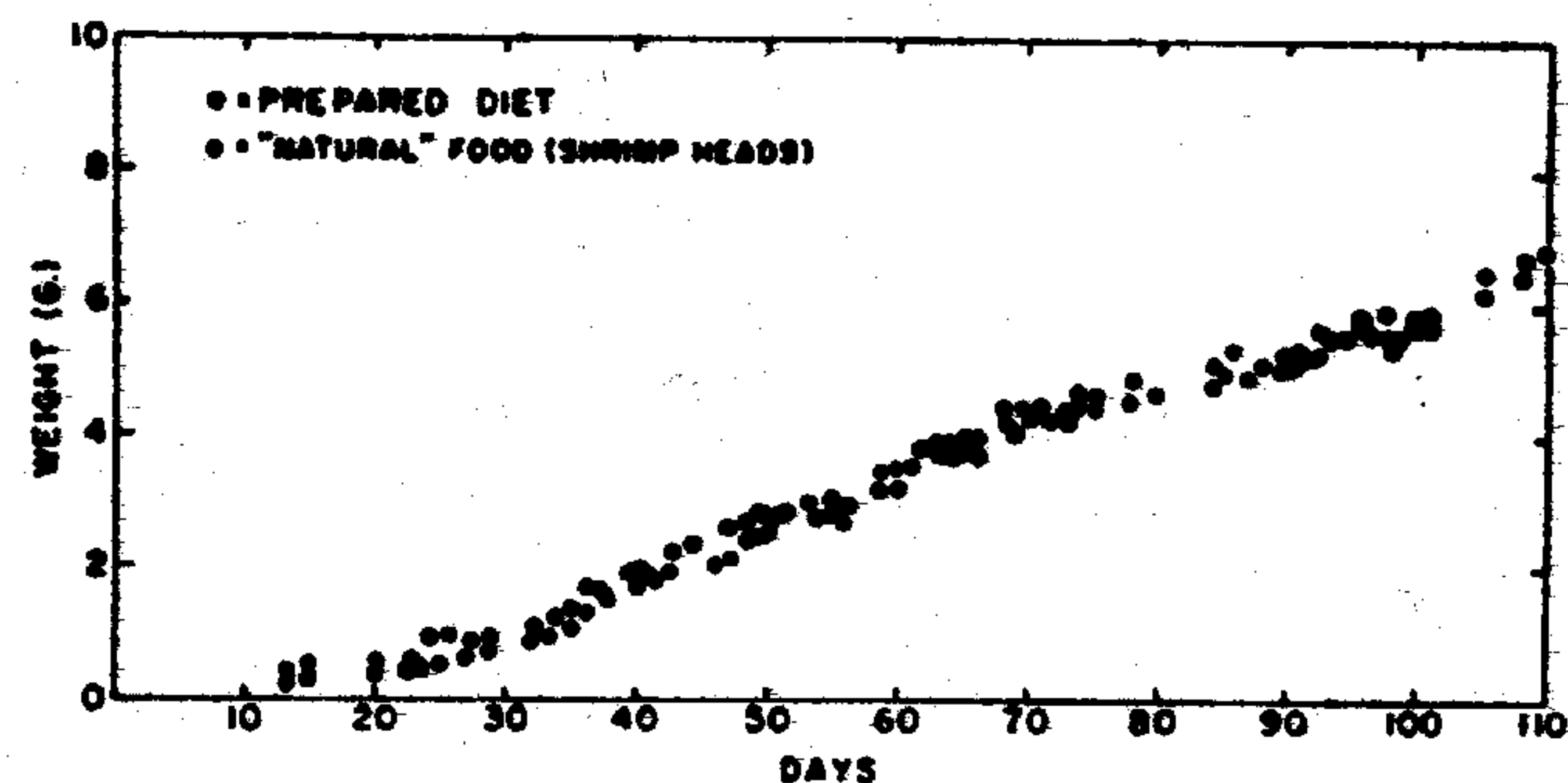


Figure 2. Growth of brown shrimp on the prepared diet and on a "natural" diet of shrimp heads.

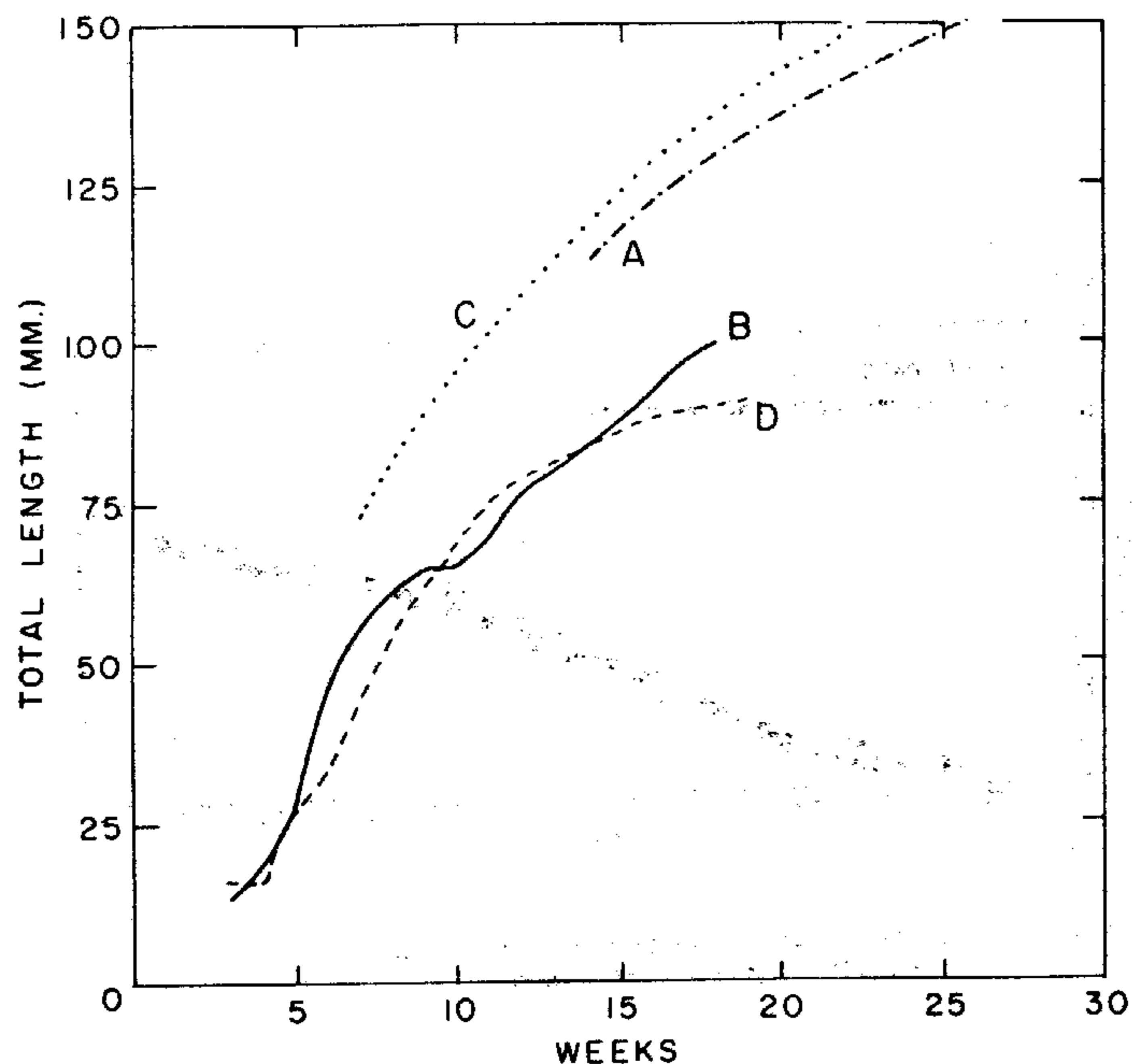


Figure 3. Representative growth curves for brown shrimp in natural and pond conditions and growth observed in this study [A - mark-recapture data (McCoy, 1968); B - pond growth reported by Wheeler (1967); C - Approximation of growth based on mark-recapture experiments in Texas (Neal, personal communication); D - Growth observed during this study on prepared diet].

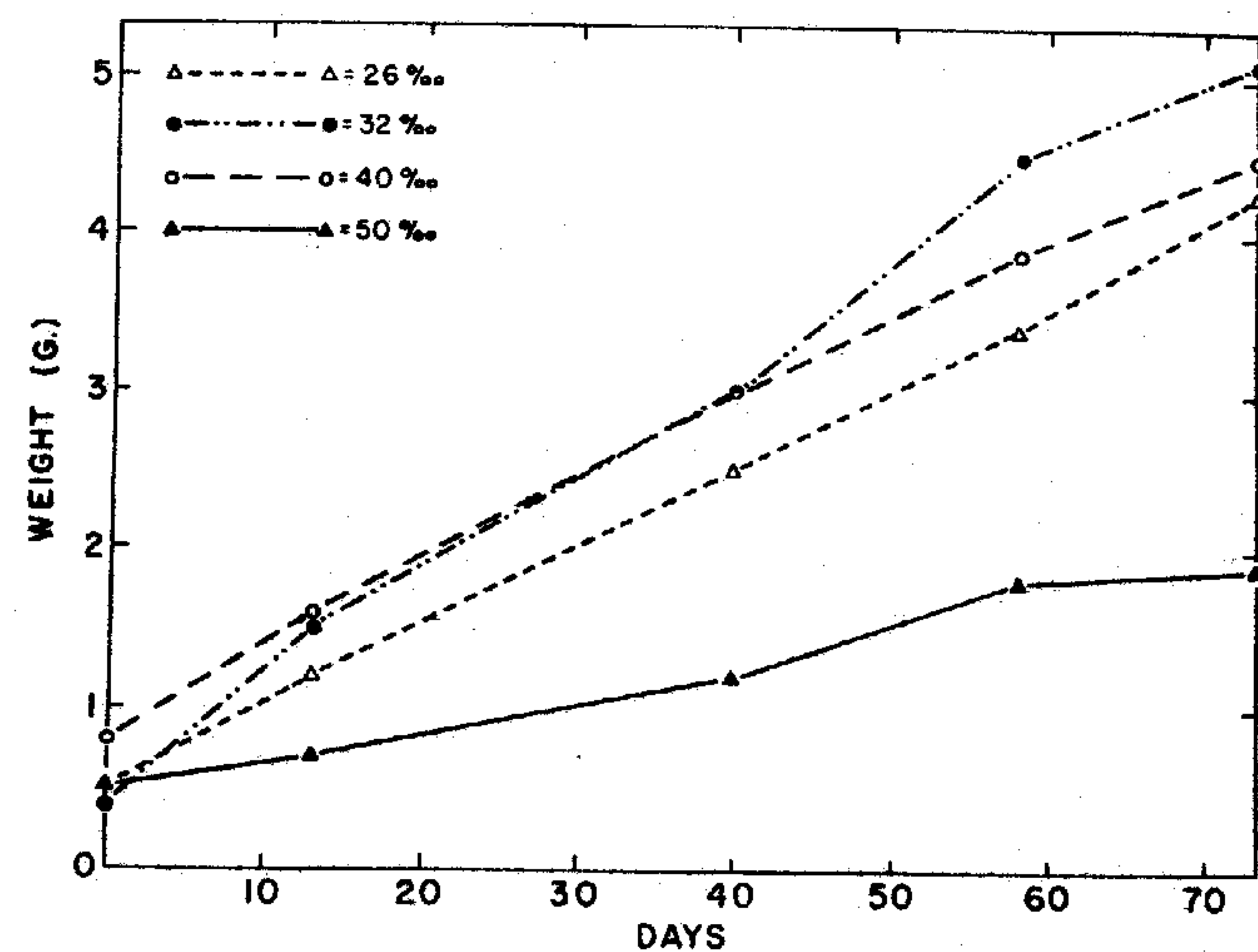


Figure 4. Growth of brown shrimp held at different salinities for a period of 70 days.

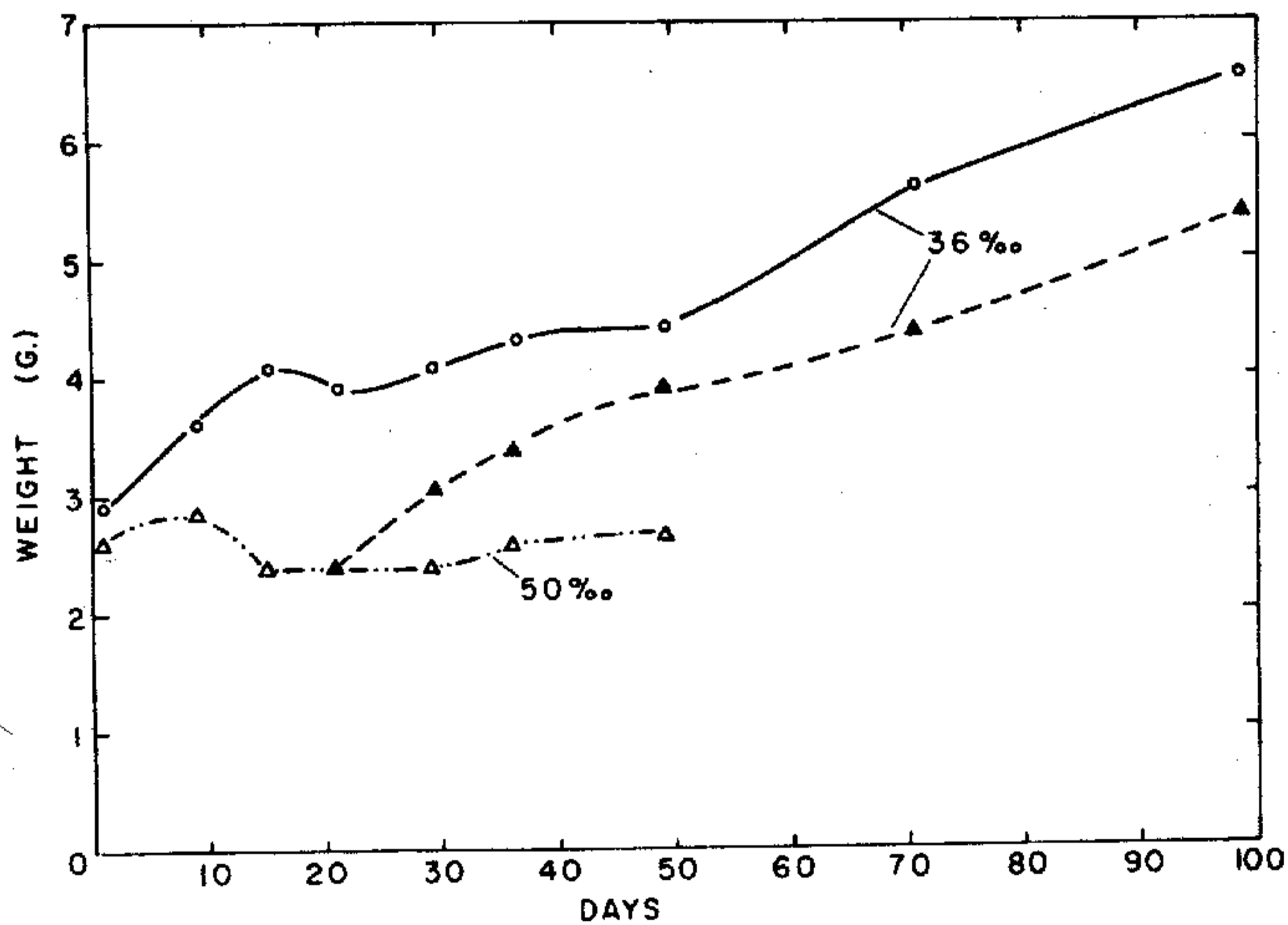


Figure 5. Growth of brown shrimp in water of 36 and 50 ppt.